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INSTRUMENTAL TESTING OF MEAT TEXTURE – COMMENTS ON THE PAST, PRESENT AND FUTURE

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Abstract. This paper summarizes briefly the current trends in meat texture research and presents concluding remarks. It is suggested that a full understanding of human sensory perception is not needed before a unified meaningful instrumental test can be adopted with practical implications in quality control, purchase specifications and consumer acceptance of meat. It is further suggested that sufficient information exists to make the selection of a unified test a reality, and that workshop sessions of interested researchers be initiated to implement this process.

The purpose of this issue has been to review the state-of-the-art in several problem areas of meat texture measurement and to illustrate some of the research avenues currently being pursued. The latter can be divided, with some liberties, into three general categories: (a) modernization and better use of existing instruments, (b) application of fundamental rheological principles both towards the improvement of instrumental measurements and towards the elucidation of the mechanical properties of meat via rheological model building, and (c) studies on structural aspects of meat aiming at the definition of parameters important to texture.

Much, if not all, of this work recognizes that texture (or tenderness) of meat is a sensory quality parameter and that a meaningful instrumental test must show a high correlation with sensory evaluation. More than with any other foodstuff, the literature on meat tenderness abounds with reports of instrumental/sensory correlations ranging from highly significant to totally non-significant (see e.g. Szczesniak, 1968). Under such circumstances, the question must be posed: is there sufficient knowledge available at the present time for different laboratories to adopt one standardized objective test?

One should differentiate here between a mechanical test applied to raw meat in order to predict the tenderness of the cooked product and an objective method for measuring the tenderness of cooked meat. The first task is extremely difficult, since it is complicated by biochemical changes and altering of the material on cooking. Heat-induced structural changes in meat affecting tenderness are discussed in this issue by Harris (1976). In spite of the progress made so far, much additional work is needed before a satisfactory predictive test can be established for raw meat. As typical examples one might mention the Armour (Hansen, 1972) and the Nip Tenderometers (Smith and Carpenter, 1973) both of which initially appeared very promising and both of which have been shown on extended testing to fail to meet the original expectations (e.g. Campion and Crouse, 1975). The question posed above shall, thus, be limited to cooked meat.

As pointed out by Penfield *et al.* (1976) and Larmond (1976) in this issue, and also by Bouton *et al.* (1976), the chemical and physical changes that meat undergoes during cooking depend on the intensity of the heat. Thus, the first problem is to standardize the heat treatment and select a method that will give the most reproducible results and the least chance of error. Cooking in a water bath, recently adopted by several researchers, appears to be promising, but must be investigated further from the standpoint of its effect on sensory discrimination (Larmond, 1976) and the relationship to the culinary methods of meat preparation such as boiling, roasting, etc.

Difficulties encountered in sampling, due to the heterogeneous nature of meat, are well known (e.g. Hansen, 1973). In recent publications, Segars *et al.* (1974) mapped variations in the apparent modulus of elasticity for five muscles and found four general areas running throughout the muscles apparently in accord with the degree of muscular activity, while Anderson *et al.* (1972) proposed a mathematical scheme for devising a total tenderness score of a carcass based on a randomization process. Using modern methods of quality control and statistical designs geared to answer the questions of the specific experiment, many of the sampling problems can be overcome.

In the area of instrumentation, the almost feverish activity of some 20–30 years ago in designing new instruments has now subsided and has given rise to both a critical appraisal of what already exists and a more fundamental approach to an understanding of (a) what the existing tests measure, and (b) what should be measured. This is probably because the more recently devised instruments (e.g. Macfarlane and Marer, 1966; Bjorksten *et al.*, 1967) have not proved to be a panacea and have been found to suffer from much of the same problems as the older ones. Thus, much useful work has recently been reported on sources of error and mode of action of instruments well established in meat texture research.

As pointed out by Voisey (1976) in this issue, the most commonly used instrument for meat texture measurements, the Warner Bratzler Shear, has now been recognized to have a number of dimensional and methodological parameters that need to be controlled and standardized. The same is true of the Texture Test System and of the deformation mechanisms in general. It appears that using the engineering approach to instrument design and performance, considerable information has been generated to allow improved reproducibility and control.

In the area of fundamental measurements, compression and tensile tests are commanding increasing attention. Tensile tests have been hailed as reflecting the type of failure that meat undergoes during the process of mastication and as a predominant feature in 'shear' tests such as those performed by the Warner Bratzler apparatus. Furthermore, they appear to reflect structural features of meat and have been linked to myofibrillar contraction and spatial changes in collagen fibers (Harris, 1976). When tensile stress is applied along the fibers, the yield is believed to reflect the strength of the structure. When tensile stress is applied perpendicular to the fibers, the resistance is due mainly to the connective tissue network (Bouton *et al.*, 1975). Compression tests are believed to give a measure of how strongly the meat fibers are held together (Bouton and Harris, 1972).

The use of tests in which the acting forces can be well defined, such as compression and tensile, is contributing significantly to a better understanding of how the meat structure reacts to the applied load and what types of forces may be involved in empirical measurements, e.g., the Warner Bratzler shear. It has been suggested, based on correlations with tensile measurements, that shear values are more reflective of muscle fiber strength than of connective tissue strength (Bouton and Harris, 1972; Penfield *et al.*, 1976). Since meats vary in the content and strength of connective tissue, and since the human response involves the characteristics of both connective tissue and fibers, this may explain the contradictory results on correlations between sensory ratings and shear values obtained by various workers.

In contrast with the past when the employed tests yielded just one force value, the more widespread use of recorders and the application of the texture profile technique allowed quantification of several parameters from the force/deformation patterns. Harris, in this issue, discusses the relationship obtained between the initial yield value in shear measurements and the structural features of meat fibers, and between the peak force values and connective tissue.

Mechanical characterization of meat as an engineering material is currently being investigated using modern methods of rheology and mechanical testing. Stoner *et al.* (1974) developed a 4-element viscoelastic model for post-mortem striated muscle, and Segars and Kapsalis (1976) report in this issue on the construction of a two-dimensional model designed to explain the behavior of a cylinder of cooked beef in uniaxial compression. They point out that the "barreling" which occurs crosswise to the applied deformation is intimately related to the cross-linking forces which hold the fibers together, a measurement that is usually overlooked in simple uniaxial compression. The model demonstrates that two samples of meat may appear very similar in uniaxial testing, and yet be widely different in the Poisson's ratio, which is the ratio of the transverse to the axial strain; this difference, if detectable by the consumer, may lower the correlation between instrumental and sensory measurements and it may account for some of the discrepancies in results among different laboratories. When combined with work on structural elements, this approach should make a valuable contribution to the understanding of the fundamental mechanical behavior of meat.

The difficulty arises when one uses mechanical parameters such as the modulus of elasticity and the ultimate strength of the material as substitutes for what the consumer perceives as tenderness, chewiness, fibrousness, etc. It is complicated by the fact that the human subject measures and integrates sensory chewing perceptions on a material that undergoes continuous transformation. It is as if testing is done on a long series of different samples which are produced not only by the mechanical destruction of the original structure, but also by the biochemical conditions in the mouth. (For a fuller treatment of this aspect of texture measurements the reader is referred to a discussion paper by Bourne, 1975.) It is clear that much more work is necessary on the psychological perception of texture.

Combining structural work with instrumental measurements and with the engineering approach to mechanical testing begins to form a bridge to the recognized multi-dimensional character of sensory meat tenderness. The need for and advances to be gained from a sounder psychorheological approach to sensory meat evaluation are discussed by Howard (1976) in this issue. The case made for the ratio estimation scales is illustrated in the successful application of this sensory rating method by Segars *et al.* (1965) leading to highly significant correlation coefficients for sensory chewiness, difficulty of cutting and residue. However, we are only beginning to see the top of the iceberg in this difficult field.

The question then is, does one need to wait for a complete understanding of human sensory responses before a unified practical test is adopted for meat texture measurements? It is suggested that the answer should be 'no'. Substantial information exists on associations between mechanical parameters quantified by different instruments and the sensory response to texture, and new data are being constantly presented in the literature. These can be extremely useful to the practical aspects of quality control, purchase specifications and consumer acceptance. Significant correlations, as well as predictive functions, can be found between instrumental measurements and sensory ratings without a full understanding of the underlying effects. Utilization of the newer findings on instrument performance, meaningful mechanical parameters and more adequate sensory scaling procedures should make such correlations sounder and statistically more significant.

It is suggested that workshop sessions of people interested in meat texture be initiated to (1) select a procedure(s) for the mechanical testing of cooked meat; (2) apply this procedure in different laboratories under standardized conditions; (3) examine and compare the results in order to suggest modifications, further work, and/or adoption of a standard test(s) on an interim and voluntary basis. In addition to a potential agreement on adopting uniform testing, this approach should also provide a proper ground for new developments and improvements.

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